

Patterns of orthopedic injuries associated with increasing e-scooter-related trauma

A retrospective observational study with a 4-year evaluation from a tertiary center in Istanbul, Turkey

Ahmet Senel, MD^{a,*}, Selman Sert, MD^a, Mehmet Akif Aktas, MD^a, Saltuk Bugra Tekin, MD^a, Engin Carkci, MD^a, Sinan Erdogan, MD^a

Abstract

The increasing use of electric scooters (e-scooters) has been accompanied by an increase in the number of traumas. Noncompliance with regulations and the effectiveness of legal measures remain subjects of ongoing debate. This study aimed to investigate the demographic characteristics of patients with e-scooter-related orthopedic injuries, temporal distribution of trauma, and patterns of these injuries. We retrospectively evaluated 534 patients with e-scooter-related injuries who were referred to the Department of Orthopedics and Traumatology between January 2020 and October 2023. Variables such as patient sex, age, time of trauma, type of hospital transfer, mechanism of trauma, injury location and type, accompanying head trauma in extremity injuries, and treatment approach were recorded. Temporal analysis was performed by hour, day, month, season, and weekday versus weekend. The majority of patients were male (80.0%), with injuries most common in the 25 to 39 age group (33.7%). Trauma was frequent in the summer (45.7%), especially in July (16.5%), with most hospital visits occurring on Fridays (18.2%) and weekends (32.2%). Blunt soft tissue injuries (47.3%) and fractures (42.4%) were prevalent, particularly in the elbow (18.4%), wrist (16.9%), and knees (14.3%). A total of 247 fractures were identified, with the radial head (17.0%) and distal radius (10.9%) being the most common fractures. Fracture rates have increased in 2022 and 2023 compared to those in previous years. While 86.0% of patients received nonsurgical treatment, 14.0% underwent surgery, with a rise in surgical cases in 2022 and 2023. Elbow (19.0%), knee (16.7%), and wrist (16.7%) were the most frequent surgical sites. The increasing use of e-scooters among young people has increased trauma cases, with a growing proportion of fractures over time. The higher incidence of injuries, particularly in the elbow and knee joints, underscores the importance of protective equipment. Therefore, additional legal regulations can help to prevent such injuries.

Abbreviation: e-scooter = electric scooter.

Keywords: e-scooter, fracture, injury, micromobility, orthopedics, trauma

1. Introduction

Globally, especially in major cities, increasing populations and traffic congestion are changing transportation preferences. Individuals have begun to turn to micromobility solutions that provide faster and more efficient transportation for short-distance travel. Micromobility is defined as vehicles that do not exceed 350 kg in weight and 45 km/h in speed.^[1] In recent years, electric scooters (e-scooters) have been frequently used for this purpose. In addition to providing ease of transportation, e-scooters offer advantages, such as easy

accessibility, reduced environmental pollution, and cost-effectiveness. Initially, e-scooter usage began with individual ownership, but over time, it became accessible through rental methods owing to mobile applications provided by commercial companies. The number of shared e-scooters is projected to increase 6-fold from 2019 to 4.6 million by 2024.^[2] In Turkey, e-scooter usage has also increased since 2019 with the emergence of commercial companies offering rental services.^[3] The 2019 coronavirus disease pandemic and trend toward social distancing have further increased interest in transportation vehicles.^[4]

The authors have no funding and conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

All study participants provided informed consent, and the study design was approved by Istanbul Training and Research Hospital Ethics Committee (date: November 10, 2023, no: 302).

This retrospective observational study has been reported in line with the STROBE Guideline.

^a Orthopedics and Traumatology Department, Istanbul Training and Research Hospital, Istanbul, Turkey.

* Correspondence: Ahmet Senel, Orthopedics and Traumatology Department, Istanbul Training and Research Hospital, Cerrahpasa, Org. Abdurrahman Nafiz Gurman Cd. No:24, Fatih, 34098 Istanbul, Turkey (e-mail: ahmetsenel23@gmail.com).

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Parallel to the rise in e-scooter usage, e-scooter-related injuries have been reported in various regions worldwide.^{15–71} Contrary to popular belief, e-scooter-related injuries often involve high-energy patterns and frequently require surgical intervention because of their severity.¹⁸¹ The head and extremities are the most commonly affected areas. Alcohol consumption, along with noncompliance with helmet and other protective equipment usage, is a significant etiological factor for severe e-scooter-related injuries.^{9,101}

Owing to the increasing number and severity of these injuries, the Republic of Turkey, like many other countries, has felt the need to implement legal regulations regarding e-scooter usage. Some of these regulations include not exceeding the speed limit of 25 km/h, not carrying passengers, not riding on pedestrian pathways, and using lights in the dark.¹¹¹ Despite these legal regulations, e-scooter-related injuries continue to occur. Noncompliance with rules and insufficient infrastructure may be cited as contributing factors.

Istanbul is Turkey's most populous city. Therefore, traffic congestion and micromobility systems are inevitable in Istanbul. As e-scooter usage has become increasingly widespread in Istanbul, e-scooter-related trauma is also on the rise. Studies conducted in centers with a high density of trauma cases have reported that e-scooter-related trauma often requires surgical intervention and that traumatic hip fractures are a significant etiological factor, particularly in young patients.^{12,131}

This study aimed to investigate the demographic characteristics of patients, types of injuries, temporal distribution, and treatment management of e-scooter-related injuries evaluated by the orthopedics and traumatology department at our high-volume trauma hospital, located in a densely populated and traffic-heavy area of Istanbul, using data from the past 4 years. The hypotheses of this study are as follows: (a) E-scooter-related injuries are increasing over time and (b) periarticular fractures are more prevalent in these traumas.

2. Patients and methods

For this retrospective study was approved by Istanbul Training and Research Hospital Ethics Committee (date: November 10, 2023, no: 302). A total of 587 patients with e-scooter-related orthopedic injuries who were referred to the orthopedics and traumatology department from the emergency department between January 2020 and October 2023 were screened from the hospital's digital archive. Patients with injuries related to other micromobility systems (such as electric motorcycles, bicycles, e-bikes, skateboards, and roller skates), incomplete records, and those without written consent for the study were excluded. Consequently, a total of 534 patients were included in the study.

Data on the patients' sex, age, time of trauma, type of hospital presentation (individual or ambulance), mechanism of trauma (simple fall, collision with a motor vehicle or pedestrian), injury site, injury type (soft tissue injury, fracture, dislocation), presence of concomitant head trauma with extremity injuries, and treatment preferences (conservative or surgical) were recorded. Injury sites were categorized by both lower and upper extremities, as well as by specific parts of the extremities (shoulder, arm, elbow, forearm, wrist, hand, pelvis, hip, thigh, knee, shin, ankle, and foot). The fracture and joint dislocation types were identified using a digital radiology archive. The timing of trauma was categorized by the time zone, day of the week, weekday versus weekend, month, season, and year. Since alcohol consumption is not routinely tested in e-scooter-related traumas at our institution and information on the use of protective equipment is insufficient, these data were excluded from the study.

2.1. Statistical analysis

SPSS software (version 25.0) for Windows (IBM Corp., New York, NY) was used for the statistical analyses. Descriptive statistics were expressed as mean, standard deviation, minimum, and maximum values for numerical variables and as numbers and percentages for categorical variables. The Kolmogorov–Smirnov

Table 1
Demographic characteristics of patients and temporal parameters of traumas.

Parameters	Mean ± SD	Min–Max
Age	28.1 ± 12.7 <i>n</i>	10–77 %
Sex		
Male	427	80.0
Female	107	20.0
Age interval (years)		
<18	100	18.7
18–24	157	29.4
25–39	180	33.7
40–49	56	10.5
>50	41	7.7
Type of hospital admission		
Ambulance	92	17.2
Individual	442	82.8
Type of trauma		
Collision with vehicle	42	7.9
Loss of balance	427	80.0
Collision with pedestrian	65	12.1
Injured individual		
Driver	489	91.6
Pedestrian	45	8.4
Year of trauma		
2020	17	3.2
2021	95	17.8
2022	218	40.8
2023	204	38.2
Season		
Winter	55	10.3
Spring	95	17.8
Summer	244	45.7
Autumn	140	26.2
Month of trauma		
January	12	2.2
February	16	3.0
March	19	3.6
April	39	7.3
May	37	6.9
June	72	13.5
July	88	16.5
August	84	15.7
September	69	12.9
October	43	8.1
November	28	5.2
December	27	5.1
Part of week		
Weekdays	362	67.8
Weekends	172	32.2
Days		
Monday	75	14.0
Tuesday	56	10.5
Wednesday	61	11.4
Thursday	73	13.7
Friday	97	18.2
Saturday	85	15.9
Sunday	87	16.3
Time interval		
00–05	101	18.9
06–11	81	15.2
12–18	190	35.6
19–23	162	30.3

test was used to test distributions. The differences in categorical variables between the independent groups were examined using chi-square analysis. A *P* value < .05 was considered statistically significant.

3. Results

The highest number of visits occurred in 2022 (218 patients, 40.8%) and 2023 (204 patients, 38.2%). A total of 427 patients (80.0%) were male and 107 patients (20.0%) were female. The average age was 28.1 ± 12.7 years (range: 10–77 years). E-scooter injuries were most frequently observed in the 25 to 39 age group, with 180 patients (33.7%). The most common cause of trauma was loss of balance, affecting 427 patients (80.0%). Of the patients, 82.8% arrived at the emergency department on their own, while 17.2% arrived by ambulance. In total, 489 patients (91.6%) were identified as drivers. E-scooter injuries occurred most frequently in the summer months (45.7%) and July (16.5%). Weekday injuries were the most common (67.8%), with the highest incidence on Fridays (18.2%), followed by Sundays (16.3%) and Saturdays (15.9%). Accidents most commonly occurred between 12:00 to 18:00 (35.6%) and 19:00 to 23:00 (30.3%) (Table 1).

Among the injuries, 47.3% were blunt soft-tissue injuries, followed by fractures (42.4%). The most frequently affected extremity regions were the elbow (18.4%), wrist (16.9%), and knees (14.3%). Head trauma was accompanied by extremity injuries in 54 patients (10.1%) (Table 2). A total of 247 fractures were identified in 233 (42.4%) patients. The most common fractures were radial head (17.0%) and distal radius (10.9%) fractures. This was followed by scaphoid fractures (7.3%) and tibial plateau fractures (5.9%). Dislocations were observed in 23 patients (4.1%), including shoulder dislocations (56.5%) and elbow dislocations (26.1%). Among the patients, 86.0% received nonsurgical treatment, while 14.0% underwent surgical intervention (Table 3). The most frequently surgically treated extremity regions were the elbow (19.0%), knee

(16.7%), and wrist (16.7%). These regions were also the most frequently treated nonsurgically (18.3%, 13.9%, and 16.9%, respectively) (Table 4). The most common traumatic injuries requiring surgical intervention were distal radius fractures (18.9%) and proximal tibia (plateau) fractures (13.5%), followed by clavicular, radial head, and proximal femur fractures (9.5% each). One patient had an surgically managed Achilles rupture. Additionally, 34 patients (6.3%) had skin lacerations that required sutures.

When analyzing the distribution by year, males were the most frequently injured sex across all years (*P* = .047). E-scooter-related injuries occurred most frequently in the summer months in all years except 2021 (*P* < .001). With the exception of 2022, blunt soft tissue injuries are the most common type of trauma annually. Concomitant head trauma was not observed in 2020 but showed an increase in 2021, 2022, and 2023 (5.3%, 10.1%, and 13.2%, respectively) (*P* = .087). Fractures were observed in 46.8% of cases in 2022 and 45.1% in 2023. Compared to the similar rates in 2020 and 2021 (35.3% and 34.7%, respectively),

Table 2
Types of injuries and distribution of injured body regions.

Parameters	n	%
Type of injury (n: 550)		
Blunt soft tissue injury	260	47.3
Fracture	233	42.4
Dislocation	23	4.1
Laceration	34	6.2
Concomitant head trauma		
Yes	54	10.1
No	480	89.9
Injured body region (n: 615)		
Upper extremity	376	61.0
Shoulder	79	12.7
Arm	2	0.3
Elbow	113	18.4
Forearm	10	1.6
Wrist	104	16.9
Hand	68	11.1
Lower extremity	227	37.0
Hip	17	2.8
Thigh	11	1.8
Knee	88	14.3
Cruris	17	2.8
Ankle	49	8.0
Foot	45	7.3
Spine	7	1.2
Cervical	1	0.2
Thoracolumbar	6	1.0
Pelvis	5	0.8

Table 3
Distribution of fractures and dislocations according to types and treatment management.

Parameters	n	%
Fractures (n: 247)		
Upper extremity	182	73.7
Acromion	1	0.4
Capitellum	2	0.8
Clavicle	16	6.5
Coronoid	8	3.2
Distal humerus	2	0.8
Distal radius	27	10.9
Forearm (both bone)	3	1.2
Hand phalanx	13	5.3
Metacarpals	15	6.1
Olecranon	5	2.0
Other carpals	10	4.0
Proximal humerus	14	5.7
Radial head	42	17.0
Scaphoid	18	7.3
Scapula	5	2.0
Ulnar styloid	1	0.4
Lower extremity	57	23.1
Bimalleolar	3	1.2
Calcaneus	1	0.4
Distal femur	4	1.6
Femoral diaphysis	1	0.4
Fibular head	1	0.4
Foot phalanx	5	2.0
Lateral malleolus	3	1.2
Medial malleolus	1	0.4
Metatarsals	9	3.6
Proximal femur	8	3.2
Tibial diaphysis	5	2.0
Tibial plafond	1	0.4
Tibial plateau	15	6.1
Spine	5	2.0
Lumbar vertebrae	3	1.2
Thoracal vertebrae	2	0.8
Pelvis-acetabulum	3	1.2
Dislocations (n: 23)		
Shoulder	13	56.5
Elbow	6	26.1
Interphalangeal	1	4.3
Acromioclavicular	1	4.3
Distal radioulnar	1	4.3
Patellar	1	4.3
Treatment (n: 534)		
Nonsurgical	459	86.0
Surgical	75	14.0

the fracture rate increased in the last 2 years (2022 and 2023) ($P = .027$). The most frequently affected extremity regions were the wrist (23.8%), knee (19.0%), and ankle (14.3%) in 2020; the elbow (21.6%), knee (18.0%), wrist (12.6%), and shoulder (12.6%) in 2021; wrist (15.6%), elbow (15.2%), and knee (14.3%) in 2022; and the elbow (20.9%), wrist (19.7%), and shoulder (13.4%) in 2023 ($P = .288$). Surgical interventions accounted for 11.8% and 11.6% of treatments in 2020 and 2021, respectively, and these rates increased to 15.6% and 13.7% in 2022 and 2023, respectively ($P = .80$) (Table 5).

A comparison by gender was also performed. Males were predominantly in the 25 to 39 age group (35.4%), while females were primarily in the 18 to 24 age group (28.0%) ($P = .095$). The majority of both males (94.1%) and females (81.3%) were drivers ($P < .001$). Both genders were primarily treated with nonsurgical methods (85.2% for males, 88.8% for females, $P = .346$). In terms of injury type, fractures were more common in males (46.8%), while blunt soft tissue injuries were more frequent in females (63.6%) ($P < .001$). Among males, the upper extremity was most commonly affected (64.2%), particularly the elbow (18.6%). For females, injuries were similar in both the upper (48.3%) and lower extremities (48.3%), with knee trauma being most frequent (20.0%), followed by elbow injuries at 17.5% ($P = .100$) (Table 6).

4. Discussion

This study included the highest number of patients reporting e-scooter-related orthopedic injuries from Turkey in the accessible literature with 4-year data. The number of E-scooter-related injuries has increased annually. Although most injuries occurred on weekdays, the highest incidence was observed on Fridays and weekends. Injuries were particularly frequent in the afternoon and evening. The summer months, especially July and August, had the highest number of incidents. Of the 534 patients evaluated by the orthopedic department, 247 fractures were identified in 233 (42.4%). The most frequently affected extremity regions were the elbow, wrist, and knees. In the upper extremity, the most common fracture types were radial head (17.0%), distal radius (10.9%), and scaphoid (7.3%), whereas in the lower extremity, tibial plateau fractures were the most common (6.1%).

4.1. Increasing e-scooter-related trauma

The increase in e-scooter use is accompanied by an increase in the frequency of related injuries.^[14,15] E-scooter-related injuries were found to have increased by 50% by 2021 compared with previous years.^[10] In Vienna, there was an 892% increase in e-scooter-related injuries from 2018 to 2019.^[7] In contrast, France reported a threefold increase in e-scooter-related injuries over a 4-year period.^[16] In the present study, e-scooter-related injuries, which constituted 3.2% of all injuries in 2020, have been steadily increasing. In 2022 and 2023, the number of traumas increased by approximately 13 times compared to 2020. This can be explained as follows. Initially, the limited number of e-scooters in our country, coupled with their use primarily for recreational purposes, may have resulted in traumas that did not require hospital visits. Additionally, the 2019 coronavirus disease pandemic has brought about numerous changes in daily life and national healthcare practices.^[17] Among these, with the concept of “social distancing” that emerged during the pandemic, transportation preferences began to shift toward individual solutions. In densely populated cities with high traffic congestion, such as Istanbul, e-scooters may have become a preferred mode of transportation for short trips, offering a motor-free electric alternative to motor vehicles. In addition, the proliferation of commercial companies offering shared e-scooter rentals has further increased their use in recent years. Finally, the environmental benefits and cost-effectiveness of these vehicles have made them attractive.

4.2. Relationship between demographic characteristics and trauma

The gender distribution among e-scooter users is nearly balanced.^[18] However, most studies have shown that e-scooter-related injuries are more common in males than in females. A systematic review of 34 studies found that 58.3% of the patients were male, while studies from our country reported that 51% to 72% of the patients were male. The average age is 25 to 34 years, with individuals aged 18 to 40 being the most commonly affected.^[2,3,19,20] In our study, 80.0% of the trauma patients were males, with the most frequently affected age groups being 25 to 39 years and 18 to 24 years. Two different

Table 4

Comparison of treatment methods according to extremity region.

Parameters	Treatment method				P
	Nonsurgical		Surgical		
	n	%	n	%	
Upper extremity	331	62.3	45	53.6	.017
Shoulder	67	12.6	12	14.3	
Arm	2	0.4	0	0.0	
Elbow	97	18.3	16	19.0	
Forearm	9	1.7	1	1.2	
Wrist	90	16.9	14	16.7	
Hand	66	12.4	2	2.4	
Lower extremity	190	35.8	37	44.0	
Hip	10	1.9	7	8.3	
Thigh	8	1.5	3	3.6	
Knee	74	13.9	14	16.7	
Cruris	12	2.3	5	6.0	
Ankle	43	8.1	6	7.1	
Foot	43	8.1	2	2.4	
Spine	6	1.1	1	1.2	
Cervical	1	0.2	0	0.0	
Thoracolumbar	5	0.9	1	1.2	
Pelvis	4	0.8	1	1.2	

perspectives on gender can be discussed. In our country, if e-scooter usage is more prevalent among males, it is expected that the trauma rate will be higher among them. On the other hand, it could be inferred that females use e-scooters more cautiously and adhere to the rules. Affected individuals are typically from active age groups, such as students or laborers, who need fast and economical transportation options during the day.

4.3. Temporal distribution of injuries over a 1-year period

The temporal distribution of e-scooter-related injuries varied throughout the year. Injuries increased notably between June and September.^[21,22] Specifically, injuries were more frequent in the afternoon and evening hours.^[20,21] Although most cases occur on weekdays, the most commonly reported days are Fridays and weekends.^[2,13,20] The results of our study, consistent with the literature, indicate that most injuries occur between 12:00 to 18:00

and 19:00 to 23:00. Notably, injuries were more concentrated from Fridays to Sundays. The summer months and September had the highest incidences of injuries. The increase in injuries during the summer months is not surprising, given favorable weather conditions. The higher frequency of injuries on weekends could be attributed to their increased use for both recreational and transportation purposes. Additionally, it can be speculated that alcohol consumption was higher on weekends. However, because our institution does not routinely assess alcohol consumption in e-scooter injuries, a definitive relationship cannot be established. Nevertheless, increased alcohol consumption on weekends has been reported in relation to e-scooter injuries.^[23]

4.4. Types of injuries

Studies from other countries and Turkey indicate that e-scooter-related injuries most frequently affect the head and upper extremities.^[7,10,13,19,24] The most common type of injury is

Table 5
Comparison of annual demographic data and traumas.

Parameters	Year								P
	2020		2021		2022		2023		
	n	%	n	%	n	%	n	%	
Sex									
Male	10	58.8	73	76.8	176	80.7	168	82.4	.047
Female	7	41.2	22	23.2	42	19.3	36	17.6	
Age interval									
<18	2	11.8	10	10.5	53	24.3	35	17.2	.165
18–24	6	35.3	30	31.6	62	28.4	59	28.9	
25–39	6	35.3	38	40.0	60	27.5	76	37.3	
40–49	1	5.9	13	13.7	23	10.6	19	9.3	
>50	2	11.8	4	4.2	20	9.2	15	7.4	
Season									
Winter	1	5.9	15	15.8	22	10.1	17	8.3	<.001
Spring	0	0.0	19	20.0	28	12.8	48	23.5	
Summer	12	70.6	29	30.5	95	43.6	108	52.9	
Autumn	4	23.5	32	33.7	73	33.5	31	15.2	
Part of week									
Weekdays	13	76.5	69	72.6	142	65.1	138	67.6	.51
Weekends	4	23.5	26	27.4	76	34.9	66	32.4	
Type of injury									
Blunt soft tissue injury	11	64.7	52	54.7	96	44.0	101	49.5	.027
Fracture	6	35.3	33	34.7	102	46.8	92	45.1	
Dislocation	0	0.0	7	7.4	8	3.7	6	2.9	
Laceration	0	0.0	7	7.4	21	9.6	6	2.9	
Concomitant head trauma									
Yes	0	0.0	5	5.3	22	10.1	27	13.2	.087
No	17	100.0	90	94.7	196	89.9	177	86.8	
Injured body region (n: 615)									
Upper extremity	11	52.4	66	59.5	147	60.2	152	63.6	.288
Shoulder	2	9.5	14	12.6	31	12.7	32	13.4	
Arm	0	0.0	0	0.0	1	0.4	1	0.4	
Elbow	2	9.5	24	21.6	37	15.2	50	20.9	
Forearm	0	0.0	3	2.7	6	2.5	1	0.4	
Wrist	5	23.8	14	12.6	38	15.6	47	19.7	
Hand	2	9.5	11	9.9	34	13.9	21	8.8	
Lower extremity	8	38.1	42	37.8	94	38.5	83	34.7	
Hip	0	0.0	3	2.7	8	3.3	6	2.5	
Thigh	0	0.0	2	1.8	6	2.5	3	1.3	
Knee	4	19.0	20	18.0	35	14.3	29	12.1	
Cruris	0	0.0	3	2.7	7	2.9	7	2.9	
Ankle	3	14.3	12	10.8	20	8.2	14	5.9	
Foot	1	4.8	2	1.8	18	7.4	24	10.0	
Spine	1	4.8	2	1.8	1	0.4	3	1.3	
Cervical	0	0.0	1	0.9	0	0.0	0	0.0	
Thoracolumbar	1	4.8	1	0.9	1	0.4	3	1.3	
Pelvis	1	4.8	1	0.9	2	0.8	1	0.4	

(Continued)

Table 5
(Continued)

Parameters	Year								P
	2020		2021		2022		2023		
	n	%	n	%	n	%	n	%	
Fractures (n: 247)									
Upper extremity	5	71.4	27	77.1	76	71.7	74	74.7	.472
Acromion	0	0.0	0	0.0	1	0.9	0	0.0	
Capitellum	0	0.0	0	0.0	1	0.9	1	1.0	
Clavicle	0	0.0	1	2.9	9	8.5	6	6.1	
Coronoid	0	0.0	1	2.9	3	2.8	4	4.0	
Distal humerus	0	0.0	0	0.0	2	1.9	0	0.0	
Distal radius	1	14.3	2	5.7	10	9.4	14	14.1	
Forearm (both bone)	0	0.0	2	5.7	1	0.9	0	0.0	
Hand phalanx	1	14.3	2	5.7	7	6.6	3	3.0	
Metacarpals	1	14.3	3	8.6	3	2.8	8	8.1	
Olecranon	0	0.0	2	5.7	2	1.9	1	1.0	
Other carpals	0	0.0	2	5.7	4	3.8	4	4.0	
Proximal humerus	1	14.3	0	0.0	7	6.6	6	6.1	
Radial head	0	0.0	8	22.9	15	14.2	19	19.2	
Scaphoid	1	14.3	4	11.4	7	6.6	6	6.1	
Scapula	0	0.0	0	0.0	4	3.8	1	1.0	
Ulnar styloid	0	0.0	0	0.0	0	0.0	1	1.0	
Lower extremity	0	0.0	7	20.0	28	26.4	22	22.2	
Bimalleolar	0	0.0	1	2.9	2	1.9	0	0.0	
Calcaneus	0	0.0	0	0.0	1	0.9	0	0.0	
Distal femur	0	0.0	1	2.9	3	2.8	0	0.0	
Femoral diaphysis	0	0.0	0	0.0	1	0.9	0	0.0	
Fibular head	0	0.0	0	0.0	1	0.9	0	0.0	
Foot phalanx	0	0.0	0	0.0	4	3.8	1	1.0	
Lateral malleolus	0	0.0	1	2.9	2	1.9	0	0.0	
Medial malleolus	0	0.0	0	0.0	0	0.0	1	1.0	
Metatarsals	0	0.0	1	2.9	2	1.9	6	6.1	
Proximal femur	0	0.0	1	2.9	4	3.8	3	3.0	
Tibial diaphysis	0	0.0	1	2.9	2	1.9	2	2.0	
Tibial plafond	0	0.0	0	0.0	0	0.0	1	1.0	
Tibial plateau	0	0.0	1	2.9	6	5.7	8	8.1	
Spine	1	14.3	1	2.9	1	0.9	2	2.0	
Lumbar vertebrae	0	0.0	0	0.0	1	0.9	2	2.0	
Thoracic vertebrae	1	14.3	1	2.9	0	0.0	0	0.0	
Pelvis-acetabulum	1	14.3	0	0.0	1	0.9	1	1.0	
Dislocations (n: 23)									
Shoulder	0	0.0	6	85.7	2	25.0	5	71.4	.123
Elbow	0	0.0	0	0.0	1	12.5	0	0	
Interphalangeal	0	0.0	1	14.3	4	50.0	1	14.3	
Acromioclavicular	0	0.0	0	0.0	0	0.0	1	14.3	
Distal radioulnar	0	0.0	1	14.3	0	0.0	0	0.0	
Patellar	0	0.0	0	0.0	1	12.5	0	0.0	
Treatment									
Nonsurgical	15	88.2	84	88.4	184	84.4	176	86.3	.80
Surgical	2	11.8	11	11.6	34	15.6	28	13.7	

soft-tissue injury.^[6] Some studies have reported that the most frequent injury type is brain injury (52%), followed by fractures (30%).^[22] In the upper extremity, the most affected area is the forearm, particularly the radius, whereas in the lower extremity, the tibia is most commonly affected.^[13,14,19] Dislocations account for 2% to 9% of injuries, with shoulder dislocations being the most common.^[3,19,20] In our study, the most common types of injury were soft tissue injuries (47.3%) and fractures (42.4%). Soft tissue injuries are more common in females, whereas fractures are slightly more prevalent than soft tissue injuries in males. According to annual distributions, although soft tissue injuries are the most commonly identified type each year, there has been an increase in the proportion of fractures in recent years. The most frequently affected body regions were the elbow, wrist, and knees. The most commonly identified fractures were radial head and distal radius fractures in the upper extremity, tibial plateau, and proximal femur fractures in the

lower extremity. Dislocations were present in only 4.1% of the patients, with shoulder dislocations being the most common. The higher prevalence of soft tissue injuries may be related to the reduction in e-scooter speed limits through legal regulations, leading predominantly to low-energy trauma. Contrary to the literature, our study identified an incidence of head trauma of 10.1%. However, since our study only included patients with orthopedic injuries referred to the orthopedic department, and head traumas were evaluated by the neurosurgery department in our institution, this may not accurately reflect the true incidence of head trauma.

4.5. Treatment options

As is well known, fractures constitute the majority of orthopedic surgical interventions.^[25] E-scooter-related fractures have increasingly become one of the etiological factors in these

Table 6
Comparison of variables according to gender.

Parameters	Gender				P
	Male		Female		
	n	%	n	%	
Age interval (years)					
<18	81	19.0	19	17.8	.095
18–24	127	29.7	30	28.0	
25–39	151	35.4	29	27.1	
40–49	40	9.4	16	15.0	
>50	28	6.6	13	12.1	
Injured individual					
Driver	402	94.1	87	81.3	<.001
Pedestrian	25	5.9	20	18.7	
Treatment					
Nonsurgical	364	85.2	95	88.8	.346
Surgical	63	14.8	12	11.2	
Type of injury					
Blunt soft tissue injury	192	45.0	68	63.6	<.001
Fracture	200	46.8	33	30.8	
Dislocation	18	4.2	3	2.8	
Laceration	27	6.3	7	6.5	
Concomitant head trauma					
Yes	47	11.0	7	6.5	.171
No	380	89.0	100	93.5	
Injured body region					
Upper extremity	318	64.2	58	48.3	.100
Shoulder	66	13.3	13	10.8	
Arm	2	0.4	0	0.0	
Elbow	92	18.6	21	17.5	
Forearm	8	1.6	2	1.7	
Wrist	90	18.2	14	11.7	
Hand	60	12.1	8	6.7	
Lower extremity	169	34.1	58	48.3	
Hip	15	3.0	2	1.7	
Thigh	9	1.8	2	1.7	
Knee	64	12.9	24	20.0	
Cruris	14	2.8	3	2.5	
Ankle	34	6.9	15	12.5	
Foot	33	6.7	12	10.0	
Spine	4	0.8	3	2.5	
Cervical	0	0.0	1	0.8	
Thoracolumbar	4	0.8	2	1.7	
Pelvis	4	0.8	1	0.8	

interventions. Although helmet or protective equipment use is approximately 5%, approximately 17% to 30% of e-scooter-related injuries require surgical intervention.^[19,26] Surgical treatment is most commonly performed for forearm and tibia fractures.^[26] In this study, 14% of the patients were treated surgically. Despite an increase in surgical interventions over the past 2 years, the rates have been relatively consistent across the years. Consistent with the literature, elbow, wrist, and knee injuries were the most common body parts requiring surgical intervention. It is likely that patients instinctively use their arms to protect themselves during falls caused by sudden and rapid balance loss, resulting in direct trauma to these areas.^[27] Therefore, it is not surprising that upper-extremity injuries require more surgical intervention. These findings suggest that in e-scooter use, not only helmets but also protective equipment for the joints are essential. To reduce injuries from these traumas, it is recommended that the use of helmets and joint protective equipment be mandated.

5. Limitations and prospects

Our study has several limitations, including its retrospective nature, the inability to access data on protective equipment

use and alcohol consumption for all patients, and the inclusion of only patients referred to the orthopedic department, which means that it does not include comprehensive data on head trauma. On the other hand, the inclusion of 4 years of patient data and having the highest number of reported orthopedic trauma cases from our country make it valuable for generalizing demographic data and injury patterns in these traumas. To clearly assess the risk factors that cause and affect the outcomes of these injuries and observe long-term disability, prospective studies with larger patient populations are needed.

6. Conclusions

The number of E-scooter-related injuries increased over time. Notably, the proportion of fractures has been rising annually. The high frequency of upper extremity injuries, especially joint injuries (both upper and lower extremities), along with the increased need for surgical intervention for these injuries highlights the importance of protective equipment use. Enhanced legal regulations such as speed limits, mandatory protective equipment, and designated riding paths may help prevent severe e-scooter-related injuries.

Author contributions

Conceptualization: Ahmet Senel, Selman Sert.

Data curation: Selman Sert, Mehmet Akif Aktas.

Formal analysis: Ahmet Senel, Selman Sert, Saltuk Bugra Tekin.

Software: Mehmet Akif Aktas, Engin Carkci.

Writing – original draft: Ahmet Senel.

Writing – review & editing: Engin Carkci, Sinan Erdogan.

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